04-14-00 A

LAW OFFICES
YOUNG & BASILE, P.C.

YOUNG, BASILE, HANLON,
MACFARLANE, WOOD & HELMHOLDT, P.C.

PATENTS, TRADEMARKS AND COPYRIGHTS
3001 WEST BIG BEAVER ROAD
SUITE 624
TROY, MICHIGAN 48084-3107

TELEPHONE (248) 649-3333
FACSIMILE (248) 649-3338

2001 COMMONWEALTH BLVD.
SUITE 301
ANN ARBOR, MI 48105-1562
TELEPHONE (734) 662-0270
FACSIMILE (734) 662-1014

700 HARRIS BUILDING
JACKSON, MI 49201
TELEPHONE (517) 787-4511
FACSIMILE (517) 787-4512
DUNCAN F. BEAMAN, RESIDENT ATTORNEY
TOWNSEND F. BEAMAN (1931-1983)

MT. CLEMENS
(810) 469-1141

GRAND RAPIDS
(616) 942-2324

THOMAS N. YOUNG
ANDREW R. BASILE
WILLIAM M. HANLON, JR.
MARSHALL G. MACFARLANE
RONALD L. WOOD
THOMAS D. HELMHOLDT
JASON J. YOUNG
TODD L. MOORE
LINDA M. DESCHERE
THOMAS E. BEJIN *
DAVID B. EHRLINGER
KATHLEEN G. MELLON
DENISE M. GLASSMEYER
JULIA CHURCH DIERKER
DARLENE P. CONDRA
CHRISTOPHER A. MITCHELL
AMANDA CONTI DUHAIME
MOLLY BASILE MARKLEY
CHRISTIAN J. GARASCIA
CHRISTIAN S. BROWER
GARY A. SMITH
ERIC L. DOYLE

*ALSO LICENSED IN MINNESOTA

04/13/00 JC644 09548757

04/13/00 JC530 U.S. PTO 09/548757

April 13, 2000

Attorney's Docket: INC-031
Box PATENT APPLICATION
Assistant Commissioner of Patents
Washington, D.C. 20231

EXPRESS MAIL LABEL NO.:
EL516817317US

Sir:

Enclosed please find an application for U.S. Patent as identified below.

Inventor: Walter J. Budd, Steve R. Hojnacki and Thomas J. Dolinshek

Invention: **ELECTRO-MAGNETIC ACTUATOR HAVING A SHORTENED MAGNETIC FLUX FLOW LOOP**

and including: Postcard; Application including 9 pages of Specification, 4 pages of claims and 1 page of Abstract; 3 sheets of informal drawings; unsigned Combined Declaration, Power of Attorney and Verified Statement Claiming Small Entity Status, Verified Statement Claiming Small Entity Status-Small Business Concern;

Filing Fee: $345.00

Please charge any deficiency or credit any excess in the enclosed fees to Deposit Account No. 25-0115.

Very truly yours,

YOUNG & BASILE, P.C.

Eric L. Doyle

ELD/slc
Enclosures

Our Reference: INC-031 PATENT

ELECTRO-MAGNETIC ACTUATOR HAVING A SHORTENED MAGNETIC FLUX FLOW LOOP

RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 60/129,161, filed April 14, 1999.

FIELD OF THE INVENTION

The subject invention relates to an electro-magnetic actuator having a shortened magnetic flux flow loop.

BACKGROUND OF THE INVENTION

Many modern vehicles include an engine and an electro-magnetic actuator for controlling a viscous fluid clutch associated with an engine cooling fan. In general operation, the clutch is designed to couple and decouple the fan and the engine. When the clutch is actuated, a rotary force is transmitted from the engine through the clutch to the fan. In this manner, the cooling fan is mechanically driven by the engine. Typically, the rotary force is produced by a water pump pulley within the engine. When the clutch is deactuated, the fan is decoupled from the engine. As such, no rotary force is transmitted from the engine to the fan. The electro-magnetic actuator is used to actuate and deactuate the clutch.

Figure 1 is a cross-sectional side view of a prior art electro-magnetic actuator 10 attached to a known type of viscous fluid clutch 12. The prior art actuator 10 includes a housing 14, a rotary shaft or core 16, a nut 18, a non-magnetic stainless steel bushing 20, a bearing 22, an electrical coil 24, and a ferromagnetic

can 26. The rotary shaft 16, includes a first end portion 28 disposed outside the housing 14 and a second end portion 30 disposed inside the housing 14. The entire shaft 16 is adapted to rotate or spin in relation to the housing 14.

The nut 18 include an inner peripheral surface 32, an outer peripheral surface 34, and a fastening means 36, such as a thread. The fastening means 36 is adapted to attach the actuator 10 to the clutch 12. When attached, the nut 18 spins with the clutch 12. The stainless steel bushing 20 is adapted to couple the first end portion 28 of the shaft 16 and the inner peripheral surface 32 of the nut 18. When coupled, the shaft 16, the bushing 20,and the nut 18 form a interface surface 38 which spins with the clutch 12.

Conventionally, the actuator 10 is threaded into a mounting and interface port 40 in the clutch 12. In this arrangement, the interface surface 38 is disposed adjacent to a spring-loaded armature plate 42 located inside the clutch 12. The interface surface 38 is spaced from the armature plate 42 to form an air gap 44.

The bearing 22 is disposed around the second end portion 30 of the shaft 16. The bearing 22 is adapted to rotatably support the shaft 16. The electrical coil 24 is disposed around the shaft 16 between the nut 18 and the bearing 22. The electrical coil 24 is adapted to receive electrical current and produce magnetic flux.

The ferromagnetic can 26 is disposed around the shaft 16. The can 26 has a peripheral surface 46 extending between the shaft 16 and the outer peripheral surface 34 of the nut 18. The peripheral surface 46 of the can 26 establishes a path for magnetic flux flow

between the shaft 16 and the outer peripheral surface 34 of the nut 18. The peripheral surface 46 of the can 26 is shaped to encase both the electrical coil 24 and the bearing 22 inside the can 26.

The electrical coil 24 forms a ring around the entire shaft 16 inside the can 26. When power is applied to the actuator 10, electrical current flows through the coil 24 producing magnetic flux. The magnetic flux flows in a loop 48, hereinafter referred to as a magnetic flux flow loop, which circles radially about the cross-sectional center point of the coil 24. The magnetic flux consists of magnetic lines of force which collectively constitute a magnetic field. The magnetic field is formed in a toroidal or doughnut like shape around the axis of the shaft 16.

The magnetic flux flow loop 48 is illustrated in Figure 1. The magnetic flux flow loop 48 extends from the first end portion 28 of the shaft 16 through the length of the shaft 16 to the second end portion 30 of the shaft 16, from the second end portion 30 of the shaft 16 along the peripheral surface 46 of the can 26 around or outside both the bearing 22 and the electrical coil 24 to the outer peripheral surface 34 of the nut 18, from the outer peripheral surface 34 of the nut 18 through the nut 18 to the inner peripheral surface 32 of the nut 18, and between the inner peripheral surface 32 of the nut 18 and the first end portion 28 Of the shaft 16 along an arch-shaped airborne path portion 50. The airborne path portion 50 of the magnetic flux flow loop 48 arches outwardly from the actuator 10 around the non-magnetic bushing 20.

When power is applied to the actuator 10, the airborne path portion 50 of the magnetic flux flow loop 48 applies a magnetic force across the air gap 44 onto

the armature plate 42 located inside the clutch 12. The magnetic force pulls the armature plate 42 inward, from a spring-loaded closed position to an open position, reducing the air gap 44 between the armature plate 42 and the interface surface 38. In the open position, the armature plate 42 permits fluid flow and coupling within the clutch 12. In this manner, the actuator 10 actuates the clutch 12.

When power is not applied to the actuator 10, the armature plate 42 returns to the spring-loaded off position. In the spring-loaded off position, the armature plate 42 restricts fluid flow and coupling within the clutch 12. In this manner, the clutch 12 is deactuated.

Although the prior art actuator 10 effectively actuates and deactuates the clutch 12, it has several shortcomings. For one, the magnetic flux flow loop 48 about the electrical coil 24 is relatively long, thereby reducing the strength of the clutch actuation force and overall electrical efficiency of the actuator 10. For another, the bearing is a separate component disposed inside the can thus requiring associated labor and assembly time. Accordingly, it would be desirable to provide an electro-magnetic actuator which overcomes the shortcomings of the prior art.

SUMMARY OF INVENTION

The present invention is an electro-magnetic actuator having a shortened magnetic flux flow loop. The actuator includes a shaft having a first end portion and a second end portion and a nut having an inner peripheral surface and an outer peripheral surface. The inner peripheral surface of the nut is coupled with the first end portion of the shaft. A bearing is disposed around the second end portion of the shaft for rotatably

supporting the shaft. An electrical coil is disposed around the shaft between the nut and the bearing for receiving electrical current and producing magnetic flux. A ferromagnetic can is disposed around the shaft having a peripheral surface extending between the shaft and the outer peripheral surface of the nut for establishing a path for magnetic flux flow there between. The peripheral surface of the can is interposed between the electrical coil and the bearing partitioning the electrical coil inside the can and the bearing outside the can. Preferably, the bearing is a circular ball bearing assembly which is insert molded into the actuator.

The present invention provides an electro-magnetic actuator having a shorter magnetic flux flow loop, a stronger clutch actuation force, and a greater electrical efficiency than prior art actuators. Additionally, insert molding the ball bearing assembly into the actuator reduces the cost of the present invention relative to prior art actuators.

BRIEF DESCRIPTION OF THE DRAWINGS

The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and wherein:

Figure 1 is a cross-sectional side view of a prior art electro-magnetic actuator attached to a known type of viscous fluid clutch;

Figure 2 is a front perspective view of an electro-magnetic actuator in accordance with the present invention; and

Figure 3 is a cross-sectional side view of the electro-magnetic actuator in accordance with the present invention attached to a known type of viscous fluid clutch.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to Figure 2, a front perspective view of an electro-magnetic actuator 110 in accordance with the present invention is illustrated. The actuator 110 is particularly suited to couple with and control a known type of viscous fluid clutch to be installed in a vehicle for the purpose of controlling the operation of an engine cooling fan via a controller, such as a thermostatic sensor.

Figure 3 is a cross-sectional side view of the electro-magnetic actuator 110 in accordance with the present invention attached to a known type of viscous fluid clutch 112. The actuator 110 includes a housing 114, a rotary shaft or core 116, a nut 118, a non-magnetic stainless steel bushing 120, a bearing 122, an electrical coil 124, and a ferromagnetic can 126. The rotary shaft 116 includes a first end portion 128 disposed outside the housing 114 and a second end portion 130 disposed inside the housing 114. The entire shaft 116 is adapted to rotate or spin in relation to the housing 114.

The nut 118 includes an inner peripheral surface 132, an outer peripheral surface 134, and a fastening means 136, such as a thread. The fastening means 136 is adapted to attach the actuator 110 to the clutch 112. When attached, the nut 118 spins with the clutch 112. The stainless steel bushing 120 is adapted to couple the first end portion 128 of the shaft 116 and the inner peripheral surface 132 of the nut 118. When coupled, the shaft 116, the bushing 120, and the nut 118 form an interface surface 138 which spins with the clutch 112.

The actuator 110 is threaded into a mounting and interface port 140 in the clutch 112. In this

arrangement, the interface surface 138 is disposed adjacent to a spring-loaded armature plate 142 located inside the clutch 112. The interface surface 138 is spaced from the armature plate 142 to form an air gap 144.

The bearing 122 is disposed around the second end portion 130 of the shaft 116. The bearing 122 is adapted to rotatably support the shaft 116. The electrical coil 124 is disposed around the shaft 116 between the nut 118 and the bearing 122. The electrical coil 124 is adapted to receive electrical current and produce magnetic flux.

The ferromagnetic can 126 is disposed around the shaft 116. The can 126 has a peripheral surface 146 extending between the shaft 116 and the outer peripheral surface 134 of the nut 118. The peripheral surface 146 of the can 126 establishes a path for magnetic flux flow between the shaft 116 and the outer peripheral surface 134 of the nut 118.

The peripheral surface 146 of the can 126 is interposed between the electrical coil 124 and the bearing 122 partitioning the electrical coil 124 inside the can 126 and the bearing 122 outside the can 126. The peripheral surface 146 of the can 126 includes a first wall 152 and a second wall 154. The first wall 152 extends radially outward from the second end portion 130 of the shaft 116 between the electrical coil 124 and the bearing 122 to a distal end 156 of the first wall 152 located beyond or outboard of the electrical coil 124. The second wall 154 extends axially with respect to the shaft 116 between the distal end 156 of the first wall 152 and the outer peripheral surface 134 of the nut 118.

In the present invention, the electrical coil 124 is disposed inside the can 126 and the bearing 122 is disposed outside the can 126. Thus, in this design, the bearing 122 can be insert molded into the actuator 110 to reduce cost. Preferably, the bearing 122 is a circular ball bearing assembly.

The electrical coil 124 forms a ring around the entire shaft 116 inside the can 126. When power is applied to the actuator 110, electrical current flows through the coil 124 producing magnetic flux. The magnetic flux flows in a loop 148, hereinafter referred to as a magnetic flux flow loop, which circles radially about the cross-sectional center point of the coil 124. The magnetic flux consists of magnetic lines of force which collectively constitute a magnetic field. The magnetic field is formed in a toroidal or doughnut like shape around the axis of the shaft 116.

The magnetic flux flow loop 148 is illustrated in Figure 3. The magnetic flux flow loop 148 extends from the first end portion 128 of the shaft 116 through the length of the shaft 116 to the second end portion 130 of the shaft 116, from the second end portion 130 of the shaft 116 along the peripheral surface 146 of the can 126 between the electrical coil 124 and the bearing 122 to the outer peripheral surface 134 of the nut 118, from the outer peripheral surface 134 of the nut 118 through the nut 118 to the inner peripheral surface 132 of the nut 118, and between the inner peripheral surface 132 of the nut 118 and the first end portion 128 of the shaft 116 along an arch-shaped airborne path portion 150.

The non-magnetic bushing 120 prohibits magnetic flux flow directly between the first end portion 128 of the shaft 116 and the inner peripheral surface 132 of the

nut 118. As a result, the airborne path portion 150 of the magnetic flux flow loop 148 arches outwardly in relation to the actuator 110 around the non-magnetic bushing 120. The airborne path portion 150 of the magnetic flux flow loop 148 is best shown arching outwardly from the actuator 110 in Figure 2.

When power is applied to the actuator 110, the airborne path portion 150 of the magnetic flux flow loop 148 applies a magnetic force across the air gap 144 onto the armature plate 142 inside the clutch 112 as shown in Figure 3. The magnetic force pulls the armature plate 142 inward, from a spring-loaded closed position to an open position, reducing the air gap 144 between the armature plate 142 and the interface surface 138. In the open position, the armature plate 142 permits fluid flow and coupling within the clutch 112. In this manner, the actuator 110 actuates the clutch 112.

When power is not applied to the actuator 110, the armature plate 142 returns to the spring-loaded off position. In the spring-loaded off position, the armature plate 142 restricts fluid flow and coupling within the clutch 112. In this manner, the clutch 112 is deactuated.

The present invention provides an electro-magnetic actuator having a shorter magnetic flux flow loop, a stronger clutch actuation force, and a greater electrical efficiency than prior art actuators. Additionally, insert molding the ball bearing assembly into the actuator reduces the cost of the present invention relative to prior art actuators.

What is claimed is:

1. An electro-magnetic actuator for controlling a clutch to be installed in a vehicle, the actuator comprising:

a shaft having a first end portion and a second end portion;

a nut having an inner peripheral surface and an outer peripheral surface, said inner peripheral surface coupled with said first end portion of said shaft;

a bearing disposed around said second end portion of said shaft for rotatably supporting said shaft;

an electrical coil disposed around said shaft between said nut and said bearing for receiving electrical current and producing magnetic flux; and

a ferromagnetic can disposed around said shaft having a peripheral surface extending between said shaft and said outer peripheral surface of said nut for establishing a path for magnetic flux flow there between,

said peripheral surface of said can interposed between said electrical coil and said bearing partitioning said electrical coil inside said can and said bearing outside said can.

2. The actuator asset forth in claim 1 including a bushing disposed between said first end portion of said shaft and said inner peripheral surface of said nut for coupling said shaft and said nut.

3. The actuator as set forth in claim 2 wherein said bushing is formed from a non-magnetic material for prohibiting magnetic flux flow directly between said first end portion of said shaft and said inner peripheral surface of said nut.

4. The actuator as set forth in claim 1 wherein magnetic flux produced by said electrical coil

flows in a loop about said electrical coil, said magnetic flux flow loop extending from said first end portion of said shaft through said shaft to said second end portion of said shaft, from said second end portion of said shaft along said peripheral surface of said can between said electrical coil and said bearing to said outer peripheral surface of said nut, from said outer peripheral surface of said nut through said nut to said inner peripheral surface of said nut, and between said inner peripheral surface of said nut and said first end portion of said shaft along an arch-shaped airborne path portion, said airborne path portion arching outwardly from the actuator.

5. The actuator as set forth in claim 4 wherein said arch-shaped airborne path portion of said magnetic flux flow loop applies a magnetic force onto a portion of the clutch when said actuator is assembled to the clutch.

6. The actuator as set forth in claim 1 wherein said peripheral surface of said can includes a first wall extending radially outward from said second end portion of said shaft between said electrical coil and said bearing to a distal end of said first wall located beyond said electrical coil, and a second wall extending axially with respect to said shaft between said distal end of said first wall and said outer peripheral surface of said nut.

7. The actuator as set forth in claim 1 wherein said bearing is an insert molded bearing fixed inside said actuator.

8. A combination of an electro-magnetic actuator and a viscous fluid clutch installed in a vehicle, the clutch having an armature plate for

controlling fluid coupling within the clutch, the actuator comprising:

a shaft having a first end portion and a second end portion;

a nut having an inner peripheral surface and an outer peripheral surface, said inner peripheral surface coupled with said first end portion of said shaft;

a bearing disposed around said second end portion of said shaft for rotatably supporting said shaft;

an electrical coil disposed around said shaft between said nut and said bearing for receiving electrical current and producing magnetic flux; and

a ferromagnetic can disposed around said shaft having a peripheral surface extending between said shaft and said outer peripheral surface of said nut for establishing a path for magnetic flux flow there between,

said peripheral surface of said bearing can interpose between said electrical coil and said bearing partitioning said electrical coil inside said can and said bearing outside said can.

9. The combination as set forth in claim 8 wherein the actuator includes a bushing disposed between said first end portion of said shaft and said inner peripheral surface of said nut for coupling said shaft and said nut.

10. The combination as set forth in claim 9 wherein said bushing is formed from a non-magnetic material for prohibiting magnetic flux flow directly between said first end portion of said shaft and said inner peripheral surface of said nut.

11. The combination as set forth in claim 8 wherein magnetic flux produced by said electrical coil flows in a loop about said electrical coil, said magnetic

flux flow loop extending from said first end portion of said shaft through said shaft to said second end portion of said shaft, from said second end portion of said shaft along said peripheral surface of said can between said electrical coil and said bearing to said outer peripheral surface of said nut, from said outer peripheral surface of said nut through said nut to said inner peripheral surface of said nut, and between said inner peripheral surface of said nut and said first end portion of said shaft along an arch-shaped airborne path portion, said airborne path portion arching outwardly from the actuator.

12. The combination as set forth in claim 11 wherein said arch-shaped airborne path portion of said magnetic flux flow loop applies a magnetic force onto the armature plate of the clutch displacing the armature plate toward the actuator and actuating the clutch.

13. The combination as set forth in claim 8 wherein said peripheral surface of said can includes a first wall extending radially outward from said second end portion of said shaft between said electrical coil and said bearing to a distal end of said first wall located beyond said electrical coil, and a second wall extending axially with respect to said shaft between said distal end of said first wall and said outer peripheral surface of said nut.

14. The combination as set forth in claim 8 wherein said bearing is an insert molded bearing fixed inside said actuator.

ABSTRACT OF THE DISCLOSURE

An electro-magnetic actuator includes a shaft having a first end portion and a second end portion and a nut having an inner peripheral surface and an outer peripheral surface. The inner peripheral surface of the nut is coupled with the first end portion of the shaft. A bearing is disposed around the second end portion of the shaft for rotatably supporting the shaft. An electrical coil is disposed around the shaft between the nut and the bearing for receiving electrical current and producing magnetic flux. A ferromagnetic can is disposed around the shaft having a peripheral surface extending between the shaft and the outer peripheral surface of the nut for establishing a path for magnetic flux flow there between. The peripheral surface of the can is interposed between the electrical coil and the bearing partitioning the electrical oil inside the can and the bearing outside the can.

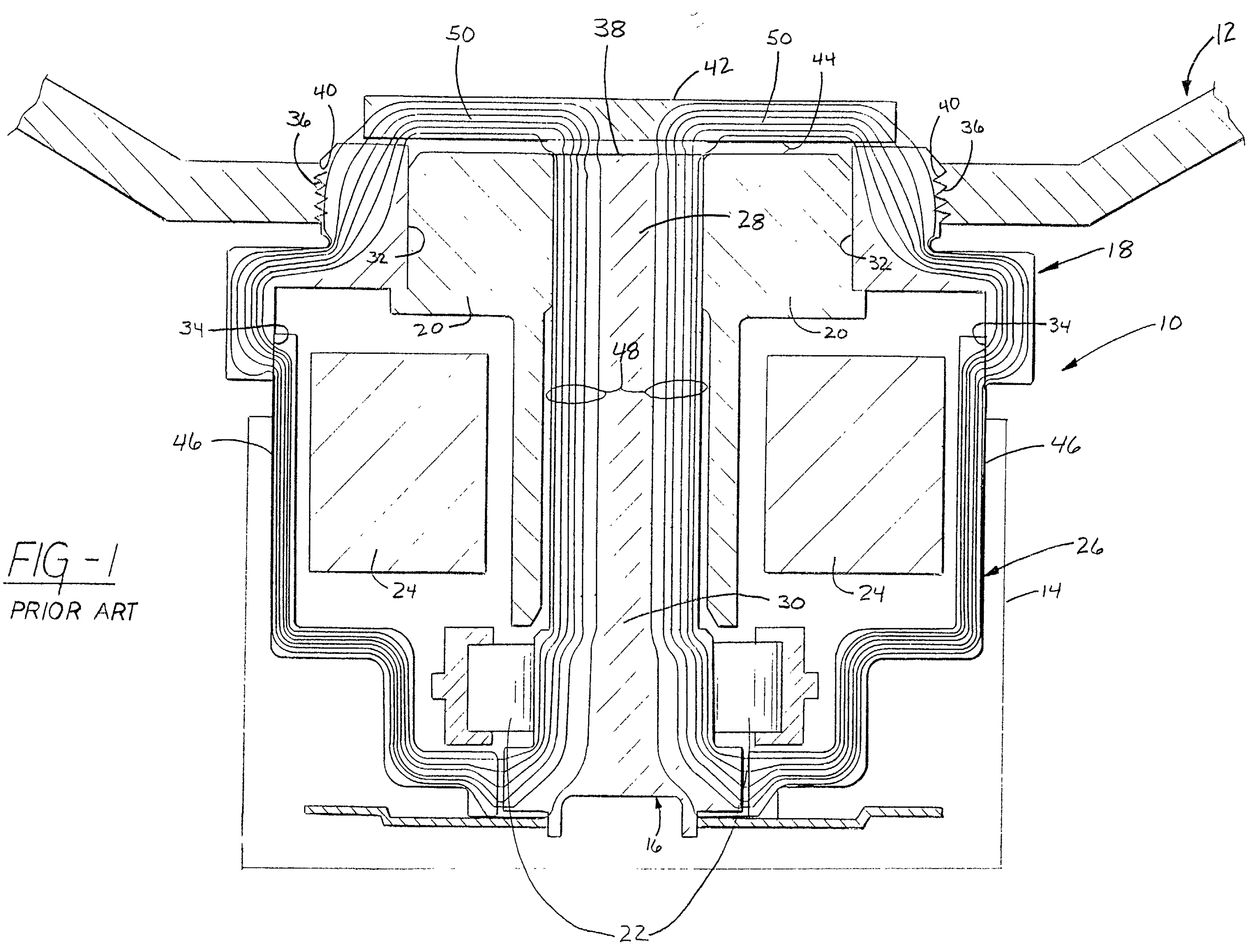
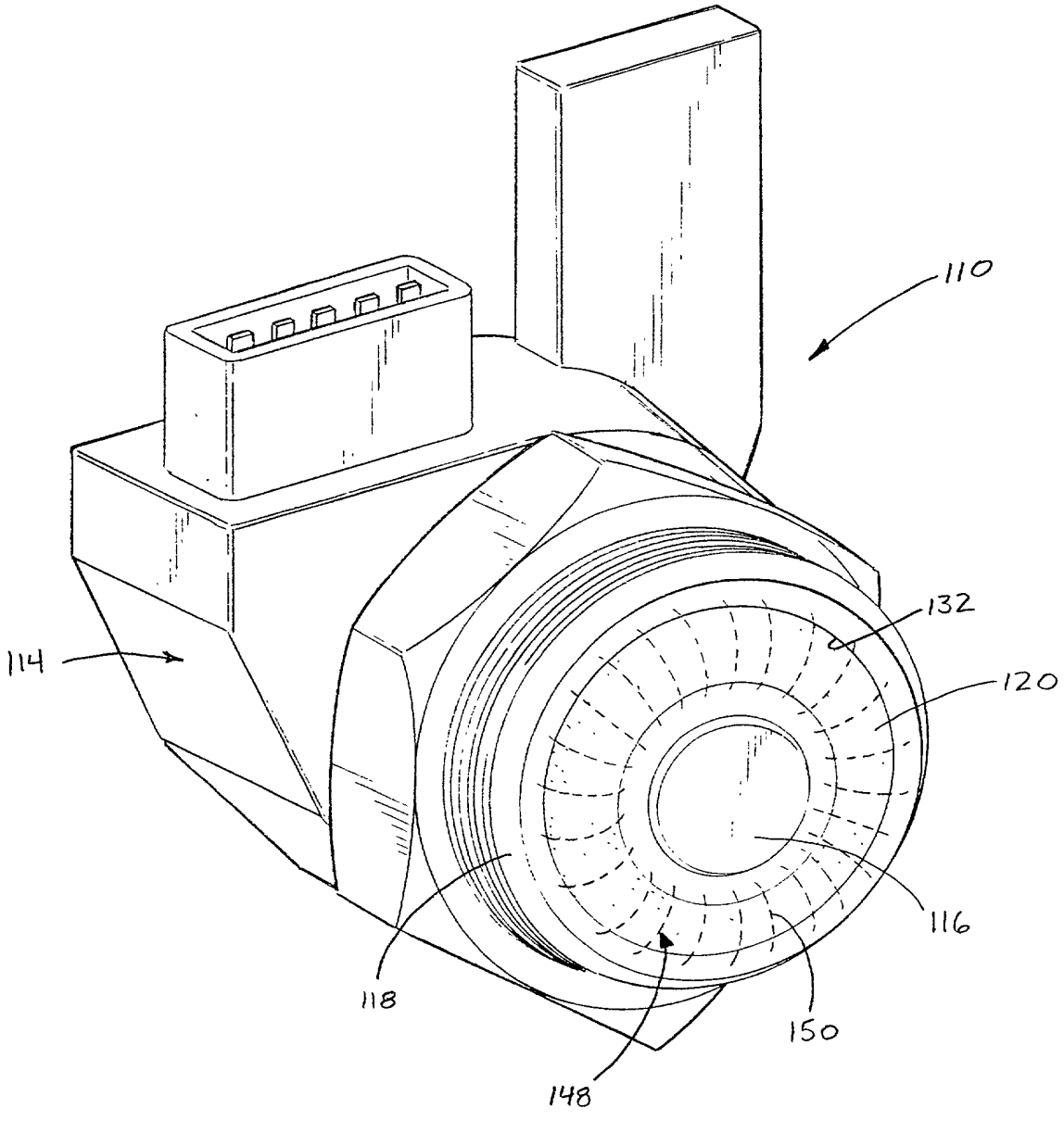


FIG-1
PRIOR ART

FIG -2



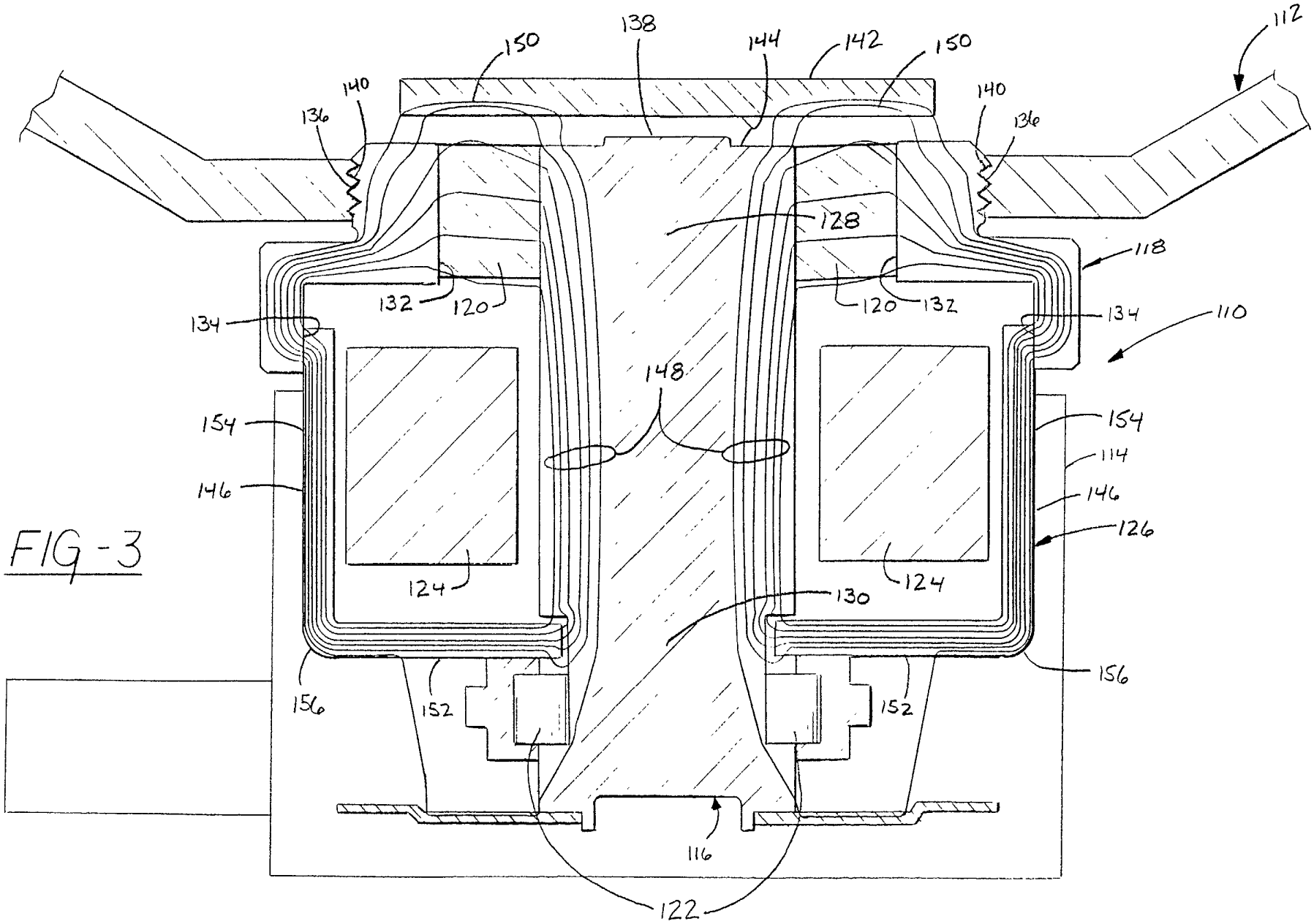

112
138
150
144
142
150
140
136
140
136
128
118
132
120
120
132
134
134
110
148
154
154
114
146
146
126
124
124
130
156
156
152
152
116
122

FIG-3

Our Reference: INC-031

COMBINED DECLARATION, POWER OF ATTORNEY AND VERIFIED STATEMENT CLAIMING SMALL ENTITY STATUS

DECLARATION:

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

ELECTRO-MAGNETIC ACTUATOR HAVING A SHORTENED MAGNETIC FLUX FLOW LOOP
the specification of which (check only one item below):

[X] is attached hereto.

[ ] was filed as United States application Serial No. _____ on _____, and was amended on or through _____(if applicable).

[ ] was filed as PCT international application Number _____ on _____, and was amended under PCT Article 19 on _____(if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate or §365(a) of any PCT international application(s) which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT international application(s) having a filing date before that of the application on which priority is claimed:

Prior Foreign/PCT Application(s) and any Priority Claims Under 35 U.S.C. §119:			Priority Claimed	
(Number)	(Country)	(Day/Mo/Yr Filed)	[ ] Yes	[ ] No
(Number)	(Country)	(Day/Mo/Yr Filed)	[ ] Yes	[ ] No

I hereby claim the benefit under 35 U.S.C. §119(e) of any United States provisional application(s) listed below.

60/129,161	April 14, 1999
(Application Number)	(Filing Date)
(Application Number)	(Filing Date)

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or §365(c) of any PCT international application(s) designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose

information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

Prior U. S. Application(s) or PCT International Application(s) Designating the U.S. for Benefit Under 35 U.S.C. §120:

(Application Number)	(Filing Date)(Status: patented, pending, abandoned)
(Application Number)	(Filing Date)(Status: patented, pending, abandoned)

POWER OF ATTORNEY:

I hereby appoint the following attorney(s) and/or agent(s) Thomas N. Young, Patent Office Registration No. 20985, Andrew R. Basile, Patent Office Registration No. 24753, William M. Hanlon, Jr., Patent Office Registration No. 28422, Marshall G. MacFarlane, Patent Office Registration No. 30403, Donald L. Wood, Patent Office Registration No. 20014, Thomas D. Helmholdt, Patent Office Registration No. 33181, Todd L. Moore, Patent Office Registration No. 36874, Eric L. Doyle, Patent Office Registration No. 42,496, and Jason J. Young, Patent Office Registration No. 34048 as my attorney(s) and/or agent(s), to prosecute this application and to transact all business in the United States Patent and Trademark Office connected therewith.

Send all correspondence to: **Thomas N. Young**
Young & Basile, P.C.
3001 West Big Beaver Road, Suite 624
Troy, Michigan 48084
Phone: (248) 649-3333

VERIFIED STATEMENT:

I hereby declare that I qualify as an independent inventor as defined in 37 CFR §1.9(c) for purposes of paying reduced fees under §41(a) and (b) of Title 35, United States Code, to the Patent and Trademark Office with regard to the above-entitled invention described in the specification.

I have not assigned, granted, conveyed or licensed and am under no obligation under contract or law to assign, grant, convey or license any rights in the invention to any person who could not be classified as an independent inventor under 37 CFR §1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR §1.9(d) or a nonprofit organization under 37 CFR §1.9(e).

Each person, concern or organization to which I have assigned, granted, conveyed or licensed or am under an obligation under contract or law to assign, grant, convey or license any rights in the invention is listed below:

[ ] no such person, concern or organization;
[X] person, concerns or organizations listed below

FULL NAME **Pontiac Coil, Inc.**

ADDRESS **5800 Moody Drive, Clarkston, MI 48348-4766**
[ ] INDIVIDUAL [X] SMALL BUSINESS CONCERN [ ] NONPROFIT ORGANIZATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor **Walter J. Budd**

Inventor's Signature_____

Date_____ Citizenship **USA**

Residence **3808 Raintree, Troy, Michigan 48083**

Post Office Address **(Same as above)**

Full name of second joint inventor, if any **Steve R. Hojnacki**

Inventor's Signature_____

Date_____ Citizenship **USA**

Residence **6310 Longleaf Pine Drive, Jupiter, Florida 33458**

Post Office Address **(Same as above)**

Full name of third joint inventor, if any **Thomas J. Dolinshek**

Inventor's Signature_____

Date_____ Citizenship **USA**

Residence **15061 Western Valley, Holly, Michigan 48442**

Post Office Address **(Same as above)**

[ ] Additional inventors are being named on separately numbered sheets attached hereto.

Applicant or Patentee: Walter J. Budd, Steve R. Hojnacki, Thomas J. Dolinshek

Serial or Patent No: _____ Attorney's Docket No.: INC-031

Filed or Issued: _____

Title: ELECTRO-MAGNETIC ACTUATOR HAVING A SHORTENED MAGNETIC FLUX FLOW LOOP

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) and 1.27 (c)) - SMALL BUSINESS CONCERN

I hereby declare that I am

[ ] the owner of the small business concern identified below:

[X] an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF SMALL BUSINESS CONCERN: Pontiac Coil, Inc.

ADDRESS OF SMALL BUSINESS CONCERN: 5800 Moody Drive
Clarkston, Michigan 48348-4766

I hereby declare that the above-identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9 (d), for purposes of paying reduced fees to the United States Patent and Trademark Office, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention, entitled ELECTRO-MAGNETIC ACTUATOR HAVING A SHORTENED MAGNETIC FLUX FLOW LOOP

by inventor(s) Walter J. Budd, Steve R. Hojnacki, Thomas J. Dolinshek described in:

[X] the specification filed herewith.

[ ] application serial no. _____, filed _____.

[ ] patent no. _____, issued _____.

If the rights held by the above-identified small business concern are not exclusive, each individual, concern or organization having rights in the invention is listed below* and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9 (c) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9 (d), or a nonprofit organization under 37 CFR 1.9 (e). *NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

NAME _____

ADDRESS _____

[ ] INDIVIDUAL [ ] SMALL BUSINESS CONCERN [ ] NONPROFIT ORGANIZATION

NAME _____

ADDRESS _____

[ ] INDIVIDUAL [ ] SMALL BUSINESS CONCERN [ ] NONPROFIT ORGANIZATION

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28 (b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING John W. Moody

TITLE OF PERSON IF OTHER THAN OWNER President

ADDRESS OF PERSON SIGNING 5800 Moody Drive, Clarkston, MI 48348-4766

SIGNATURE _____ DATE 4/4/00

W:\INC032 VST